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OPTIMAL DELIVERY OF REMEDIAL MATHEMATICS PROGRAMS IN U.S. HIGHER EDUCATION

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OPTIMAL DELIVERY OF REMEDIAL MATHEMATICS
PROGRAMS IN U.S. HIGHER EDUCATION

by

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Abstract

Remedial mathematics has been considered the roadblock to obtaining a college degree by students and educators for years. The purpose of this research is to determine the optimal time and delivery method of the three presented (fully module, module with a traditional lecture component, and fully on-line) for teaching remedial mathematics. This is accomplished by comparing pass rates. First, pass rates are compared to determine if there is a statistically significant difference between pass rates in the two models for teaching remedial mathematics (pre-requisite and co-requisite). Next, pass rates are compared to determine if there is a statistically significant difference between pass rates in the two models for teaching remedial mathematics for students who score below 14 on the mathematics portion of the ACT. Last, pass rates are compared to determine if there is a statistically significant difference between pass rates in the three delivery methods presented. Samples of students from a large community college located in the Mid-South were used in the study. Hypothesis tests were conducted. A test of proportions was used to test the hypothesis regarding the best time to teach remedial mathematics. A chi-square test of independence was used to test the hypothesis regarding the better delivery method for teaching remedial mathematics. The results of this research indicate that the co-requisite model leads to higher pass rates for students in their remedial mathematics course overall as well as for students who score below 14 on the mathematics portion of the ACT. The results of this research indicate that there is no significant difference in pass rates of students in the delivery methods presented. Based on these findings, the co-requisite model for teaching remedial mathematics is the better model. Future research is needed in the area of the better delivery method.

Table of Contents

Table of Contents

List of Tables

Chapter One

Introduction

Remedial Mathematics has been considered the roadblock to obtaining a college degree by many students and educators for years. The term remedial can be described as basic skills that are necessary for success in college-level courses (Cohen & Brawer, 2008). A surprisingly large number of students begin their college journey by taking a remedial mathematics course. According to Goldrick-Rab and Cook (2011, p. 258), approximately 40% of college students require at least one remedial course and more than 20% of college freshman are enrolled in remedial mathematics. The problem is more pronounced in two-year colleges where approximately 60% of first-time freshmen students are required to take a remedial mathematics course (Klipple, 2017). In the past, this has delayed entry into college-level courses. It has also caused the student to be separated from his or her college-level peers as well as adding semesters and sometimes years to graduation (depending on the number of remedial courses required). Policy makers as well as remedial mathematics teachers have re-invented the wheel many times over the years with the goal of finding what works best for these students who begin college at the remedial level and thus need the most assistance in their journey to college graduation. Questions regarding when to take the remedial mathematics course in relation to the college-level mathematics course, as well as the best method of delivery for the course have spurred many discussions among educators.

Remedial mathematics can be taught as either a pre-requisite course or a co-requisite course. When taught as a pre-requisite course, a student would be required to take and pass one or more remedial mathematics courses prior to being allowed to take a college-level mathematics course. On the other hand, when taught as a co-requisite course, the student would take both a remedial mathematics course as well as a college-level mathematics course at the same time. The

remedial mathematics course would be paired with the corresponding college-level mathematics course with the goal of providing just in time remediation for the college-level topics.

With the help of technology, there are many ways of course delivery at the disposal of educators. Specifically, there is fully traditional lecture, fully module, fully on-line, module with some lecturing, and hybrid courses that combine traditional classroom lecture, module, and on-line delivery. Which method of delivery leads to the greatest level of success for the remedial mathematics student?

In this study, I investigated the pre-requisite model versus the co-requisite model as well as three delivery methods for teaching remedial mathematics in community colleges. I examined two primary issues regarding the two models. First, I investigated which model has the better success rate overall (this includes all students who score 18 or lower on the mathematics portion of the ACT). Next, I investigated which model has the better success rate for those students who score less than 14 on the mathematics portion of the ACT. I also investigated the various delivery methods for teaching remedial mathematics. The goal of the study is to compare the competing models as well as delivery methods to determine what leads to the better overall way to teach remedial mathematics. I investigated which model (pre-requisite versus co-requisite) leads to higher pass rates in remedial mathematics courses, as well as which delivery method leads to higher pass rates in remedial mathematics courses.

It is important to note that students who score less than 14 on the ACT deserve additional research for several reasons. For those who score below 14, they are considered to be in the bottom 6% of those taking the ACT Mathematics exam (ACT, 2016, p. 1). This means this group needs more remediation than those who, for example, scored closer to the college-level mark with a 16 or 17 on the mathematics portion of the ACT. When remedial mathematics was

taught in the traditional lecture format, students who scored below 14 had to take a series of three pre-requisite courses, Basic Math, Elementary Algebra, and Intermediate Algebra, prior to beginning a college-level mathematics course. Students who had to take all three remedial mathematics courses would have to wait a year and a half before taking a college-level mathematics course. The cost to the student and the time added to completion in remedial mathematics led to this group of students having extremely low retention and graduation rates.

Background of the Study

Beginning in the Fall 2015 semester, all colleges in the Tennessee Board of Regents (TBR) purview replaced the pre-requisite model for remedial mathematics with the co-requisite model through the co-requisite remediation policy that required the shift from pre-requisite to co-requisite (TBR, 2018a). TBR consists of 40 institutions in Tennessee, which includes 13 community colleges and 27 colleges of applied technology. The Board of Regents establishes policies that are implemented throughout the system (TBR, 2018b). Policy makers in the TBR system mandated that all community colleges in Tennessee move to the co-requisite model. Tennessee was not alone in this shift. Other states, such as Maryland and Texas, were front runners in the shift to co-requisite remediation (Complete College America, 2012). Colorado was one of the first states in the nation to implement a state policy calling for co-requisite remediation (Complete College America, 2018). Tennessee was the first state in the nation to fully implement the co-requisite model (Mangan, 2015a).

TBR began referring to remedial mathematics courses as learning support when the module-based model was introduced. Prior to the Fall 2015 semester, at TBR institutions, learning support was a pre-requisite course. Students who needed remediation in mathematics had to complete their remedial mathematics courses prior to taking a college-level mathematics

course. In other words, a student would first take a learning support mathematics course to learn the necessary pre-requisite competencies for his or her college-level mathematics course. Once the student passed the pre-requisite learning support mathematics course, then he or she could take a college-level mathematics course the following semester. Under the co-requisite model, the student takes both the co-requisite course and the corresponding college-level course during the same semester. The co-requisite model provides just-in-time remediation for the college-level course that is being taken at the same time as the co-requisite course ("Tennessee Board of Regents Co-requisite Remediation Model Produces Giant Leaps," 2016). For example, the co-requisite remedial mathematics course provides lecture and practice problems for remedial topics that are necessary to understand prior to learning a new concept in the college-level mathematics course. The two courses are paired together, and topics in each are scheduled in such a way that the student receives the remediation necessary to understand and support the college-level concepts at just the right time. The remedial mathematics course also provides extra practice and help with the more complicated college-level topics.

Students are placed in the remedial or learning support pre-requisite and co-requisite courses based on ACT scores. Students who score 18 or lower on the mathematics portion of the ACT are placed in a co-requisite learning support course as well as a corresponding college-level mathematics course. As long as the student passes both courses the first time he or she enrolls in them, then the student will complete both the required remedial work in mathematics as well as a college-level mathematics course in one semester.

In addition to determining the best time to teach remedial mathematics topics to those who score 18 or lower on the mathematics portion of the ACT, and those who score less than 14 on the mathematics portion of the ACT, it is important to determine the better delivery method

4

for teaching remedial mathematics. The three main delivery methods are traditional lecture (fully lecture), module, or on-line. Colleges are now offering several variations of these methods including hybrid (classes that meet in a person for half the hours and on-line for the other half) as well as module classes that include a traditional lecture. The main delivery method options specifically for the remedial mathematics courses are fully module, module with some traditional lecture, and fully on-line (in module format). Students are left with the decision of which delivery format to take and often do not understand the advantages and disadvantages of each.

Statement of the Problem

The problem that led to this research is persistently low pass rates of students in remedial mathematics. Specifically, the concern is the low pass rates of students who score 18 or below on the mathematics portion of the ACT in remedial mathematics courses as well as those who score less than 14 on the mathematics portion of the ACT. By implementing the co-requisite model, TBR is attempting to solve the problem of low pass rates in remedial mathematics courses as well as low retention and low graduation rates of students who begin college at the remedial level in mathematics. The main objective of the co-requisite model is to increase pass rates in both the co-requisite course, as well as the corresponding college-level course. A long-term goal is to increase retention and graduation rates for students who begin college in need of remediation in mathematics. Policy makers, politicians, and educational leaders believe that the co-requisite model could double the number of remedial students passing their college-level courses (Mangan, 2013). TBR also expects students to progress at a faster pace under the co-requisite model. For example, a student may complete his or her learning support course by mid-semester. At that point, he or she can spend more time on the college-level course, and possibly complete it early as well. In summary, the objectives or goals of the co-requisite model include

increasing the pass rate of the course itself, increasing the pass rate of the corresponding college-level course, increasing retention rates, and increasing graduation rates for students who begin college in need of remedial mathematics. First, this research focuses on how students who scored 18 or below on the mathematics portion of the ACT perform in the co-requisite model compared to how they perform in the pre-requisite model. Then it focuses on how students who scored less than 14 on the mathematics portion of the ACT perform in the co-requisite model compared to how they perform in the pre-requisite model. Last, the research compares the different delivery methods for remedial mathematics.

The reason TBR is requiring colleges to use the new co-requisite model is the belief that remedial mathematics is a roadblock to retention and graduation for college students (Mangan, 2015b). By allowing students to take a college-level course at the same time as the co-requisite course, students will see the benefit of the co-requisite course immediately. The intent is that students will also experience an early success in their corresponding college-level course.

In the past, students who tested into remedial mathematics were required to a take pre-requisite course that was most often taught in a format with all students working at the same pace. The problem with this delivery method is that students who failed the course had to start over again the next semester. Often, students in remedial mathematics have various deficiencies, and this delivery method required that all students learn all remedial topics at the same pace. This led to educators coming up with new delivery methods to allow students to work at their own pace as well as only on the remedial topics that are individually necessary. Thus, the module-based delivery format was born. This delivery format allows students to work at their own pace as well as only on topics where they need remediation. For example, at community colleges in Tennessee, the module-based remedial mathematics course allows students to "test-

out" of a remedial competency early if the student can show mastery of the competency. Once a competency is passed, the student never repeats that competency even if he or she fails that course. If a student does not pass the co-requisite mathematics course and thus has to re-take it, he or she will only re-take the modules that were not previously passed. This allows students to work at their own pace on competencies that are needed individually. At community colleges in Tennessee, all remedial mathematics courses are currently offered in a module format. The question remains, which delivery method is better for these courses: fully module, module that includes a traditional lecture, or module-based in the fully on-line format?

Purpose of the Study

TBR has reported that the co-requisite model leads to student success at significantly higher rates than the previous pre-requisite model for students who begin their college journey in need of remedial mathematics (Complete College America, 2018). This research specifically addresses the pass rates of students who score 18 or below on the mathematics portion of the ACT thus requiring them to take remedial mathematics. Then it addresses the pass rates of students who score less than 14 on the mathematics portion of the ACT. In other words, is there is a statistically significant difference in pass rates of students who score 18 or below on the ACT in pre-requisite learning support mathematics versus co-requisite learning support mathematics, and is there is a statistically significant difference in pass rates of students who score less than 14 on the ACT in pre-requisite learning support mathematics versus co-requisite learning support mathematics? Community colleges have historically represented students with lower ACT scores at high rates and thus have a large percent of students who begin their college journey with the remedial mathematics requirement. Since the module-based model (pre-requisite and co-requisite) is being used exclusively at community colleges in Tennessee to

address students who need remediation in mathematics, it is important to determine which module-based model leads to higher success rates for these students, the pre-requisite or the co-requisite model. This question addresses the timing of the teaching of the remedial topics. In addition to addressing this question, this research also addresses which delivery method leads to higher pass rates for students in remedial mathematics courses. In other words, is there a statistically significant difference in the pass rates of students in fully module-based, module-based with some traditional lecture involved, or module-based but fully on-line remedial mathematics courses? In summary, the purpose of this research is to determine the best timing and delivery method of the three presented for teaching remedial mathematics. In other words, are students more successful under the new co-requisite model than the previous pre-requisite model for teaching remedial mathematics? Also, are students more successful in fully module-based, module-based with some traditional lecture involved, or module-based but fully on-line remedial mathematics courses?

The co-requisite learning support course included in this research is Math 0530. This course represents the support or co-requisite course for the corresponding college-level course Elementary Statistics (Math 1530). The pre-requisite learning support courses include Math 0810 and Math 0820.

This study focuses on students at Sunrise Southern Community College (SSCC), a pseudonym for a community college located in the Mid-South. It serves a large portion of students who score on the lower end of the mathematics section of the ACT which makes it a suitable site for this research.

Purpose Statement

The purpose of this research is to determine the best time to teach learning support mathematics as well as the better delivery method for teaching learning support mathematics. This was done by comparing pass rates to determine if there is a statistically significant difference between the pass rates in the two learning support models (pre-requisite and co-requisite) as well as the various methods of delivery (fully module, module with a traditional lecture component, and fully online module-based).

Guiding Research Questions

To achieve the purposes of this study, this research intends to answer the following guiding questions:

1. What is the difference in the mean pass rates of students who took a co-requisite learning support mathematics course compared to those who took a pre-requisite learning support mathematics course at SSCC?

2. What is the difference in the mean pass rates of students who scored less than 14 on the mathematics portion of the ACT who took a co-requisite learning support mathematics course compared to those who took a pre-requisite learning support mathematics course at SSCC?

3. What is the difference in the mean pass rates of students in fully module, module that includes a traditional lecture, and fully on-line learning support mathematics courses that are module-based at SSCC?

It is important to note that passing remedial mathematics courses is defined by scoring 70% or higher on all module exams. For remedial mathematics courses this means that the

student has an overall average of 70% or higher in the course and scored 70% or higher on all module exams (Southwest Tennessee Community College, 2018b, p. 3).

Potential Significance of the Study

Understanding the best time (pre-requisite or co-requisite) for students testing at the remedial level of mathematics to take the class as well as the better delivery method is significant in improving retention and graduation rates for these students. Once community college advisors, faculty and administrators understand what works better for these students, then classes can be structured in such a way to lead to overall success and higher pass rates. What is learned at SSCC from this research can be applied to other community colleges. Since remedial mathematics has long been a roadblock to graduation for many students, increasing pass rates can potentially lead to higher graduation rates for students who historically have graduated at extremely low rates. Identifying the best overall model for teaching remedial mathematics would also allow community colleges to invest more in the model that shows the highest success rates.

Theoretical Framework

The theoretical framework that guides this study is self-directed learning. Since module-based courses generally involve students working at their own pace, self-directed learning is a common adult learning theory for these college students. Merriam (2001) defines self-directed learning as "learning that is widespread, that occurs as part of adults' everyday life, and that is systemic yet does not depend on an instructor or classroom" (p. 8). According to Boucouvalas and Lawrence (2010), "self-directed learning takes place as learners practice doing the real thing, adapting what is necessary from models and working on their own, receiving assistance only at their request" (p. 47). A key to self-directed learning is that the learner takes responsibility for his or her learning (Hansman & Mott, 2010; Knowles, 1975; Merriam, Caffarella, &

10

Baumgartner, 2007).   The module-based delivery allows students to watch lectures and complete homework, quizzes, and exams at any time, therefore it is imperative that the student in this type of course takes responsibility for his or her own learning. A student in the module-based format needs to be able to work on his or her own, receiving assistance when needed, and must take responsibility for seeking out that assistance.

Assumptions and Limitations

It is assumed that there are potentially other variables that can impact the pass rates of students in remedial mathematics classes. Overall pass rates are used in the data analysis of this research. Since there are many variables that could impact student success rates, data regarding demographic information will be provided. Of most importance, average ACT score for each cohort will be provided in chapter four. This will provide insight regarding the variability between cohorts throughout the pre-requisite and co-requisite courses as well as the various delivery methods that are used in the analysis for this research.

In order to address potential variability in cohorts, a control group was be utilized. During the Fall 2015 semester students taking Math 1530 included those who passed pre-requisite learning support during the Spring 2015 semester as well as those taking the co-requisite learning support course during the Fall 2015 semester. The pass rates of students who passed pre-requisite learning support (during the Spring 2015 semester) or co-requisite learning support (during the Fall 2015 semester) and Math 1530 (during the Fall 2015 semester) will be compared in chapter four. This group of students represents the control group as this is the only time a college level course included both students from pre-requisite learning support and co-requisite learning support at the same time.

This research is limited to students at SSCC. Students outside of SSCC, and thus outside the state of Tennessee, are not included in this study. Students outside of community colleges are not included in this study. Also, only students who test into remedial level mathematics are included in this study. Therefore, the results of this research cannot be generalized to all college students.

Definition of Terms

There are several terms used in this study that require definition for complete understanding. These terms are as follows:

Remedial Mathematics Students. For the purposes of this research, remedial mathematics students are those who are placed in a remedial mathematics class based on scoring 18 or lower on the mathematics portion of the ACT or equivalent test. This is a TBR requirement.

Learning support. A term used to describe the course remedial mathematics students take. Specifically, the learning that takes place in this course should support the learning that takes place in the corresponding college-level mathematics course.

Pre-requisite. For purposes of this research, a pre-requisite remedial mathematics course is required to be taken prior to taking a college-level mathematics course.

Co-requisite. A form of learning support that occurs when the learning support course is offered at the same time as the corresponding college-level course.

Module. A delivery method for learning support courses. It is used to indicate the way a course is divided into sections (modules) on a computer. For example, most module-based remedial mathematics classes are divided into several modules and each module contains a form of lecture, homework, quiz, and exam all delivered on the computer.

Module-based courses are often designed to allow students to work at their own pace thus providing the potential to work ahead and complete courses early.

Self-directed learning. A theory of adult learning that will be further addressed in the next section, theoretical framework.

Summary

Students who begin their college journey in remedial mathematics have historically had low pass rates, retention rates, and graduation rates. The purpose of this research is to determine the best time and better delivery method of the three presented for teaching remedial mathematics with the hope of increasing the overall academic success of this group of students. Self-directed learning is the theoretical framework that guides this study.   A literature review of self-directed learning as well as the background of the problem, and what others have done in an attempt to solve the problem follows. The methodology section will then outline the research design.

Chapter Two

Literature Review

The purpose of this study is to determine the best timing and delivery for teaching remedial mathematics, or learning support mathematics. Learning support mathematics courses have been taught as pre-requisite courses and co-requisite courses. Learning support mathematics can also be delivered in a variety of ways. This study will focus on the three main delivery methods for teaching learning support courses: fully module, module with a traditional lecture component, and fully on-line (module-based).

A thorough literature review was conducted and will be presented in this chapter. Complete College America provided basic information for both the learning support and the co-requisite models for teaching remedial mathematics. Literature from various scholarly sources provided insight into the success of projects related to learning support and the co-requisite model as well as background on self-directed learning.

This section will begin by providing a history of community colleges. This will be followed by a review of remedial education and why it is often a roadblock for college students in the areas of completion and graduation. A discussion of why community college students were chosen for this study will be provided. In other words, why is this research topic important to community colleges and community college students? Literature will also be provided to support why students who score under 14 on the mathematics portion of the ACT were of special interest for this study. Next, a literature review of the pre-requisite model and co-requisite model for learning support mathematics will be presented. A review of literature will be provided for the different methods of delivery: module, lecture, and on-line. Also, a literature review of self-directed learning and why it was chosen as the adult learning theory that will guide this research

will be discussed. This section will conclude by explaining the gap in literature that this research sets out to fill.

Community College History

Community colleges in America date back to the early twentieth century. Increasing numbers of graduates from high school played a major role in the growth of community colleges. By the twentieth century, education was expected to solve society's problems such as unemployment and inequitable incomes (Cohen & Brawer, 2008). "Probably the simplest overarching reason for the growth of community colleges was that an increasing number of demands were being placed on schools at every level. Whatever the social or personal problem, schools were supposed to solve it" (p. 2).

According to Cohen and Brawer (2008), one of the most notable changes that community colleges brought to American education is increased access to higher education. After World War II, the rate of college going increased greatly. Beginning with the Serviceman's Readjustment Act of 1944 and concluding with the explosive enrollments in community colleges in the 1970s, this period was the most expansive in America for higher education (Geiger, 2011; Geller, 2001). "The creation of community colleges altered the definition of higher education to encompass a broader array of vocational and academic opportunities" for more individuals (Callan, 2001, p. 84). Community colleges were the biggest contributor to opening the system of higher education to the masses. They were established in every metropolitan area and available to everyone. This was attractive to all those who had been left out of higher education in the past, especially those who had done poorly in high school and would not have had the opportunity to participate in higher education without community colleges.

When enrollments increased, there was a shift in the student body who attended college (Cohen & Brawer, 2008). This new student body affected the curricula offered by community colleges. Remedial education became a larger part of the curricula and new types of support systems and learning laboratories were utilized by community colleges. As the number of underprepared students enrolling in college grew, so did developmental education. "The apparent breakdown of basic academic education in secondary schools in the 1960s, coupled with the expanded percentage of people entering college, brought developmental education to the fore" (p. 25). According to Cohen and Kisker (2010), the declining ability of those entering college in the 1960s lead to increased remediation studies being offered, especially in community colleges.

Since the 1970s, there has been an acceleration in the trend toward remedial education in community colleges. According to Cohen and Brawer (2008), "Standing outside tradition, they offered access" (pp. 33-34). In other words, community colleges have an open-door policy to allow access to everyone. Both academically and socioeconomically, the majority of community colleges students come from the lower half of those completing high school. In general, the socioeconomic status of those attending community colleges is lower than those attending four-year institutions. By the 1980s it became apparent that as community colleges were working to maintain enrollments, they were attracting students with a "casual commitment to college-level studies" (p. 71). All of this solidified that remedial education would be an important mission of community colleges.

During the early years of the community college, achievement tests were administered with the goal of properly placing students in courses that matched the level of the student's ability. Around the early 1970s, there was a shift in this practice as students demanded to choose their own courses. Educators saw that it was difficult to accurately assess students. Thus the

1970s "saw an erosion of course pre-requisites" (Cohen & Brawer, 2008, p. 75). During the 1980s the movement shifted toward the completion of programs. During this time, "one of the first requirements was to test the students at entry, place them in programs commensurate with their aspiration and abilities, and demand that they make steady progress toward completing the program" (p. 76). As legislators took a greater interest in appropriate student placement, due to a concern over high dropout rates of community college students, the required testing and appropriate placement of students spread throughout the 1980s.

The need for, and role of, developmental programs at community colleges has been around for many years. Programs and policies have come and gone; however, questions remain regarding how to best serve this population of students.

Remedial Education

The term remedial education has been used interchangeably over the years with terms such as developmental and basic education. Remedial refers to any college class that is below college-level. College credit is not earned by students taking remedial courses (Bautsch, 2013).

According to Goldrick-Rab and Cook (2011), one of the most notable changes in higher education is the decline in the level of academic preparation of its students. This decline is in part due to widening participation. As more students from a variety of backgrounds enter higher education, their level of academic preparedness has declined. The result has been an increase in the number of remedial students in higher education. Remedial students, as well as the reasons that lead the students to remedial placement, are diverse. Remedial placement can be the result of a student showing deficiency in one of more subjects (generally reading, writing, or mathematics), older students who have forgotten skills that were learned in high school and need a refresher course, students with poor study habits, student with learning disabilities, and recent

immigrants who struggle to understand English (Cohen & Brawer, 2008). According to Callan (2001), students who come from low-income backgrounds disproportionately find themselves in need of remediation. Most colleges use college entrance exams such as the ACT and SAT, or a placement exam administered by the college to determine if a student needs to enroll in remedial coursework (Bautsch, 2013).

Over 50% of community college students nationwide are in need of remediation (Bautsch, 2013, p. 1). As the number of remedial students enrolling in colleges, specifically community colleges, has increased, there has been an increasing demand for a redesign of remedial education. The high cost of remediation has also led to the demand for improving remedial education. In fact, the cost of remedial education is estimated to be approximately 2.3 billion per year (p. 2). In addition, dropout and failure rates are unconscionably high for those enrolled in remedial courses (Cohen and Brawer, 2008). According to Adelman (as cited in Cohen & Kisker, 2010), students who begin their college journey in remedial courses are less likely to graduate than those who are deemed college ready. Bastedo (2011) asserts that state officials and policy makers are concerned about the increase in remedial education that is offered to underprepared students and the resulting lower persistence rates. This historically "broken" and costly remedial education system led to the learning support models for remedial mathematics courses which is the focus of this research.

The Remedial Roadblock

According to Goldrick-Rab and Cook (2011, p. 258), 63% of students from the bottom socioeconomic quintile are in need of remediation. Overall, approximately 50% of all community college students enroll in at least one remedial course. Drop out and failure rates are extremely high for these students. In fact, when remedial mathematics was offered as a series of

up to three courses, only 12% of students who enrolled in remedial mathematics completed the courses after two years in the state of Tennessee (Complete College America, 2018). Thus, remedial mathematics has been labeled "the roadblock to graduation" (Ibid.).

Other states have experienced the same issue. For example, in California, only 16% of students who begin their college journey in remedial coursework complete a 2-year degree or certificate within 6 years (Watanabe, 2016, para. 2). A U.S. Department of Education study showed that 27% of students enrolled in remedial mathematics earn a bachelor's degree, compared to 58% of students who did not require remediation in mathematics (Bautsch, 2013, p. 2).

The fact is that the majority of remedial students never graduate (Complete College America, 2012). It is important to identify the best way to serve these students. This research seeks to compare several different delivery methods and times for teaching remedial mathematics. Specifically this research seeks to determine, how the success rates of this group of students can be maximized.

Community College Students

Community colleges provide an option for students with low ACT scores through open access. Students are accepted regardless of their ACT score. This often results in community colleges supporting a high percent of students in need of remediation. Challenges remain in the area of success for these students. Only 30% of community college students nationwide receive a degree or certificate (Quarles & Davis, 2017, p. 34). In order to improve the success of community college students, a significant amount of attention has been given to remedial courses. Nationally, remediation programs vary greatly in their delivery methods as well as their goals (Ibid.). In general, the goal of remediation programs and courses is to provide the students

the necessary skills for success in college-level courses. This study first examines the best time for taking the remedial mathematics course. In other words, do students learn the remedial skills better when completing the remedial course prior to enrolling in a college-level mathematics course? Or, do students learn the remedial skills better if they are taught at the same time the student is taking a college-level mathematics course that requires the use of the remedial skills? Once the best time for teaching remedial mathematics was examined, this research addresses the better delivery method of the three presented for teaching remedial mathematics. In other words, which delivery method leads to higher success rates in remedial mathematics courses? Since community colleges support a high percent of students who need remediation, community college students are the focus of this research with the goal of determining the best time and better delivery method for remedial mathematics courses.

Benchmark Significance of Standardized College Entrance Examinations

In Tennessee, students seeking college entrance generally take the ACT Exam. The ACT is a multiple course exam and is divided into four subject areas: English, reading comprehension, mathematics, and science (ACT, 2018). Student mathematics scores on the ACT are of particular interest to this research as this is the score used by colleges in Tennessee to determine if a student is in need of remediation in mathematics thus placing the student in a learning support course. The questions on the mathematics portion of the ACT include pre-algebra and elementary algebra, intermediate algebra, geometry, and trigonometry concepts (Johnson & Kuennen, 2006).

Students who score less than 14 on the ACT mathematics portion are considered less than high school prepared in the area of mathematics. Prior to fall 2013, students who scored less than 14 on the ACT portion of the ACT were required to take three remedial mathematics

courses prior to taking a college-level course in Tennessee. Under the pre-requisite model, students were required to pass two learning support courses prior to enrolling in college-level mathematics courses. Under the co-requisite learning support model, this group of students is now required to only pass one learning support course and it is taken at the same time as the corresponding college-level mathematics course. There is a concern among educators that this group of students is now placed at a disadvantage as these lower scoring students are required to work at the same pace and level as those students who barely miss the mark of being college ready in the area of mathematics.

A study by Johnson and Kuennen (2006) supports the assertion that this group of students, those scoring less than 14 on the mathematics portion of the ACT, deserves special consideration. The goal of their study was to identify student characteristics associated with student success in the college-level mathematics course, introductory statistics. This study included 292 individual survey results. The surveys were administered on the first day of the 2004 Fall semester to six sections of an introductory statistics course. Three different professors gave identical exams to students in each of their sections. The dependent variable in this study was ending course grade, and the independent variable was ACT score. Results of this study indicate that:

> Very basic mathematics skills are among the most important indicators of student success in a course where many of the skills directly assessed (such as analyzing data with descriptive statistics, hypothesis testing, or linear regression) are not necessarily of a basic skills nature. (p. 3)

The results of this study support the concern among educators that those students who score at the lower end of the ACT, and thus generally struggle with very basic mathematics skills, are at a

disadvantage when placed in a co-requisite learning support mathematics course and a college-level mathematics course and expected to complete both in one semester. The specific concern is that this group of students is expected to work at the same pace as those who barely miss the mark of being college ready and therefore placed directly in college-level courses.

Learning Support – Pre-requisite versus Co-requisite

One of the big arguments against pre-requisite learning support is the length of time required to complete the sequence of required courses and the associated cost of the coursework. Historically, remedial learning support, required pre-requisite coursework. This coursework costs hundreds of millions of dollars due to the large number of students who needed to take multiple remedial mathematics courses. Credits earned from remedial, or learning support, courses do not count toward a degree. Another disadvantage of learning support as a pre-requisite is that it becomes a roadblock to students' progression toward their college degree. "For most, remediation will be their first and last college experience – a tragedy that is disproportionally true for low-income students and students of color" (Complete College America, 2018). According to the executive summary published by Complete College America (2018), one out of three recent high school graduates need remediation. A number many consider too high. In addition to high numbers of students enrolled in remedial courses, very few succeed in completing the associated introductory college-level course. In fact, only 20% of students enrolled at two-year institutions and 36% of students enrolled in four-year institutions completed the associated introductory college-level course within two years. Only 17% of students who begin in non-credit remedial courses will graduate (Ibid.).

Where there was once a bridge to nowhere but college debt, disappointment and drop out, today there is a new, proven bridge to college success – a bridge that is spanning the divide between hope and attainment. We call it Co-requisite Remediation. (Ibid.)

A study reported in Complete College America's executive summary examined traditional lecture remedial mathematics courses (taught as pre-requisites to college-level mathematics courses). This study included 12,747 remedial mathematics students during 2008 and 2010 in Tennessee at two-year institutions. The study resulted in 17% of the students completing their associated introductory college-level mathematics course and 35% of the students completing their remedial mathematics courses (Ibid.). These low completion numbers led to the introduction of learning support courses, first as a pre-requisite and later as a co-requisite, that are taught in module format. The module format allows students to work both at their own pace as well as the ability to test out of competencies that the student already has a good understanding of.

The co-requisite model for remediation has resulted in the doubling and tripling of success rates of students in their associated introductory college-level course. In a 2014 pilot study in Tennessee, 61% of students completed their associated introductory college-level mathematics course in one semester as opposed to the national average of 12% of students who completed their associated introductory college-level mathematics course in two years (Ibid.). These numbers indicate that the co-requisite model is indeed successful at increasing success rates of students in remedial as well as the associated introductory college-level mathematics courses in the state of Tennessee.

Nationally, 51.7% of students enrolled in two-year colleges enroll in remedial courses, 22.3% of those students complete both their remedial coursework and their associated

23

introductory college-level course in two years (Complete College America, 2014). Only 9.5% of students who begin at the remedial level graduate within three years. This low pass rate, as well as even lower graduation rate, of students who begin their college journey in remedial courses is a problem that educators hope learning support courses offered in module format will fix.

It is easy to see that driving factors behind the co-requisite learning support model include addressing the following issues with traditional remedial mathematics courses: a staggering number of students who enroll in remedial courses, the high cost associated with remedial course work, and a one-size fits all remedial algebra based course that is only useful to those who will eventually need calculus (Ibid.). Since the co-requisite learning support courses allow students to work at their own pace, the ability to test out of competencies early, and the ability to never repeat previously passed competencies, it is the hope of educators that the co-requisite learning support model leads to higher success rates in both remedial coursework as well as the corresponding college-level mathematics courses.

The Tennessee Board of Regents (TBR) mandated that all of its 13 community colleges implement the co-requisite learning support model no later than the Fall 2015 semester. At the end of the fall semester, 51% of students completed their associated introductory college-level mathematics course and over 51% completed their co-requisite course ("Tennessee Board of Regents Co-requisite Remediation Model Produces Giant Leaps," 2016). According to Tristan Denley, the Vice Chancellor of Academic Affairs for TBR, TBR will continue to look at data with the intent of identifying areas that need attention. Individual institutions will also be examined ("Tennessee Board of Regents Co-requisite Remediation Model Produces Giant Leaps," 2016). It is important to examine individual institutions as the characteristics of the student populations various across college campuses. Sunrise Southern Community College

(SSCC) has a student population that is different from other populations in Tennessee. Specifically, SSCC has more students scoring at the lower end of the ACT than any other college in Tennessee. This study focuses on students at SSCC and will thus address this gap.

Delivery Method

The three main delivery methods investigated in this study include fully module, module with a traditional lecture component, and fully on-line (module-based). Module-based learning has been mandated by TBR for community colleges in Tennessee. The work required to be completed in the course is divided into a set number of modules and delivered on a computer using Pearson's MyLabsPlus. The fully module delivery method indicates that everything necessary for the student to learn is contained within each module (including a lecture, practice problems, quizzes, and an exam). The students meet the teacher face-to-face; however, traditional lecture in not incorporated into the course delivery. Fully-online (module-based) is where the course is still delivered in a module format; however, the students do not have face-to-face contact with the instructor. This module-based format is fairly new to the literature therefore there is a need to conduct research in this area. What is available in the literature is a study on traditional lecture versus on-line delivery.

Can students in on-line courses be as successful as students who meet with faculty face-to–face in a traditional lecture format? In a study by Pope (2013), the means of the scores of students in on-line learning support mathematics courses were compared to those in a traditional lecture based learning support mathematics course. In this study, the online course was module-based. This is a good comparison of the learning support model of remedial mathematics and the traditional lecture model that was the precursor to learning support due to the fact that on-line learning support class was based on the same design as module-based courses. Both courses in

the study used Pearson's MyMathLab for the homework assignments. The instructor used the same syllabi, content and assignments in both courses. The study was performed at West Georgia Technical College. The study included 96 online (module) students and 601 traditional (lecture) students. The results of COMPASS tests and final grades were used to perform an independent samples t-test. The result of this study was that there was insufficient evidence to rule out that the observed difference between the means of the scores of the online (module) and traditional (lecture) students was due to chance (Pope, 2013).

Other Reported Results

Many colleges have run pilot sections of the co-requisite model and have found it to be more successful than previous models that required low scoring students to complete a remedial course prior enrolling in a college-level course. For example, at Austin Peay State University, students who enrolled in a co-requisite mathematics course and a corresponding introductory college-level mathematics course simultaneously "succeeded at more than twice the rate of those who previously took the traditional pre-requisite developmental courses. For example, the pass rate of developmental students in Elements of Statistics rose from 23 percent to 54 percent" (Complete College America, n.d.).

Texas State University, San Marcos, ran pilot programs during two semesters, summer 2008 and summer 2010 (Complete College America, n.d.). Students who scored near the college-level cut-off score were allowed to simultaneously enroll in remedial mathematics and one college-level course, either college algebra or college algebra with statistics. This pilot was referred to as the FOCUS program. Students in this program received two hours of tutoring each week that occurred on the same day as their mathematics class. Results indicate that students in the FOCUS program successfully completed their college-level mathematics courses at

significantly higher rates than non-participants. During the summer of 2008, 88% of students successfully completed College Algebra; 74% completed College Algebra during the summer of 2010 (p. 3). Successfully completed implies a grade of A, B, or C was earned. All entering remedial students successfully complete a college-level mathematics course at a rate of 37.4% (p. 3). The results from this study, as well as the study from Austin Peay State University, indicate that students have higher success rates when taking remedial mathematics courses at the same time as introductory college-level mathematics courses. The question remains, is this true for all students? Specifically, what works best for students at the lower end of the college-level cut-off score?

Self-directed Learning

Self-directed learning is the theoretical framework that guides this study. Self-directed learning is an adult learning theory that helps to define adult learners as being different from children (Merriam, 2001). Taking the primary initiative to learn is a key concept in self-directed learning (Merriam et al., 2007). Self-directed learning takes place as the learner takes the initiative and responsibility for his or her own learning. Self-directed learners are internally motivated. Malcolm Knowles was a pioneer of self-directed learning. According to Knowles (1975), self-directed learning is a process where the learner takes the initiative to diagnose his or her learning needs, identify learning resources, choose appropriate learning strategies, and implement them. Self-directed learning does not necessarily depend on an instructor or classroom (Merriam, 2001). Hansman and Mott (2010) added that adult learners are those who are capable of directing their own learning and are internally motivated. Similarly, Hansman (2001) stated that self-directed learning occurs as learners practice doing the task.

It is important to note that both the learning support and co-requisite model for remedial mathematics are self-paced and utilize key aspects of self-directed learning. Self-directed learning can also be defined as

> The growing ability to understand oneself as a learner and develop the capacity to assume one's internal directedness even in other-directed environments, to know how to learn but also when one might need to be taught, and to take responsibility for one's learning or non-learning. (Boucouvalas & Lawrence, 2010, p. 41)

> Self-directed learning can be thought of as "adults assuming control of their learning" (Hansman & Mott, 2010, p. 17). In module-based courses, students have the ability to move through the course at their own direction. Students can work ahead and finish the course early. It is especially important in module-based courses that students are self-directed learners. Students in these courses must take the initiative and be willing to work outside the classroom.

According to Grow (1991), "students have varying abilities to respond to teaching that requires them to be self-directing" (p. 126). Grow's response to this observation is the Staged Self-Directed Learning (SSDL) Model. The goal of this model is to help students to become more self-directed in their learning. Specifically, the fundamental movement is from a dependent learner to a self-directed learner. An important aspect of this model is readiness. Grow defines readiness as a combination of ability and motivation. Grow asserts that the ability to be self-directed in learning can be situational but is not entirely situational. According to Grow, "it is partly a personality trait analogous to maturity" (p. 127). Grow also states that self-directedness in learning can be transferable to new situations, and self-direction can be learned as well as taught. Grow's SSDL Model consists of four stages. In stage one, the student is dependent and the teacher is the coach. In stage two, the

student is interested and the teacher is the motivator or guide. In stage three, the student is involved and the teacher is the facilitator. The final stage, stage four, is where the learner is self-directed and the teacher is the consultant.

Educators, such as Mark Tennant, have expressed concerns over how one can diagnose the stage of readiness of the learner (Grow, 1994). In Grow's (1994) response to Tennant's concern, Grow asserts that the teacher is the best judge of the self-directed learning readiness level of a student. Grow states, "I am suspicious of concepts that draw major conclusions from simple quantifiable measures" (p. 111). According to Grow, "every stage requires balancing the teacher's power with the student's emerging self-direction" (p. 140).

The learning support courses have the flexibility to allow students to learn at whichever stage he or she is in. Specifically, the teacher has the flexibility to demonstrate, coach, motivate, and facilitate in the learning support courses. Grow (1991) asserts that fully self-directed learning in an institutional setting is not possible. Instead, it is the most important outcome for adult learners in a formal educational setting.

Studies show that the majority of adults are not college or work-force ready in the area of mathematics. "Two out of every five 18- to 64-year-olds do not have the basic skills in reading and mathematics to succeed in college or today's skilled workforce" (Ginsberg & Wlodkowski, 2010, p. 28). The mathematical knowledge of students spans a wide range. "Educators must find ways to reach adult learners 'where they are' and promote critical reflection in learning situations to help further learners' growth and development in increasingly complex societies" (Hansman & Mott, 2010, p. 21). The module-based learning support courses are set up in such a way that students can focus on their individual needs. The students can work where they are. They are in control of their learning.

In both the learning support and co-requisite model of remedial mathematics, students are in control of their own learning, which is an important aspect of self-directed learning. "The student is in control of determining how much practice he or she needs in order to master a skill" (Steinke, 2012, p. 57). In self-paced courses such as the pre-requisite and co-requisite learning support models, it is up to the student to determine how fast or slow he or she will move through the material. Studies have indicated that self-paced students out-perform traditional students (Davis, 2013). This could be due to the repetitive nature of the course. It could also be because the course is more meaningful since the student is in control of his or her learning, which is a key aspect of a self-directed learning environment. It is important for colleges to offer flexibility in classroom formats to allow students "to explore independence in their learning with the goal that all students would have learned how to learn by the time they graduate" (Closson, 1996, p. 16). Self-paced courses are one way colleges have addressed this. Both the pre-requisite and co-requisite learning support models are only taught as self-paced courses in Tennessee. In fact, due to the self-paced nature of the learning support model, many students will complete it early and then be able to use the time in that course to work on their corresponding college-level course. In other words, a student who completes a learning support course before the end of the semester can use the remaining time in the course to work on his or her corresponding college-level course.

While researching personalized learning practices, Feldstein and Hill (2016) found a noteworthy example at Essex County College (ECC) in Newark, New Jersey. The majority of the students at ECC were required to take remedial mathematics courses. The majority of those students who were required to take remedial mathematics did not pass their remedial mathematics course. Feldstein and Hill (2016) also found that of those who did pass their

remedial mathematics course, the majority did not pass their associated introductory college-level mathematics course. Leadership at the college found that students placed into remedial mathematics courses came from an enormous range of prior knowledge. Some students had the equivalent of a fourth-grade mathematics education. Other students only needed to review a few topics to be ready for college-level mathematics. Students on the lower end of the spectrum felt lost in remedial mathematics; whereas, those on the higher end felt bored. The result in both cases was high failure and drop-out rates. ECC implemented Self-Regulated Learning. Courses offered in the Self-Regulated Learning format allowed students to work in a computer lab at their own pace and receive individual assistance from their teacher as needed.

Many aspects of the Self-Regulated Learning format were similar to how both the pre-requisite and co-requisite learning support models for remedial mathematics were implemented at SSCC. Similarities include the reason behind the model as well as the self-paced nature. According to Feldstein and Hill (2016), a driving factor on the policy side behind the redesign of remedial mathematics across the nation is a shift in thinking from access to college to graduation from college and the fact that remedial mathematics has been a roadblock to graduation for many college students for years.

Gap in the Literature

This study was conducted at a community college and focused on two groups of remedial mathematics students. First, it focused on students who score 18 or less on the mathematics portion of the ACT. This is the group of students who is required to take learning support mathematics. Then the study focused on a subgroup of these students. Specifically, this study focused on those students who scored less than 14 on the mathematics portion of the ACT. This group is of particular interest as scoring less than 14 on the mathematics portion of the ACT

indicate that the student is not at high school level. Under the learning support pre-requisite model for teaching remedial mathematics, this group of students was required to take two pre-requisite remedial mathematics courses prior to taking a college-level mathematics course. Under the co-requisite model, this group now takes one co-requisite mathematics course at the same time as an introductory college-level course. In other words, this group is now treated the same as all other students who score 18 or less on the ACT. This makes them of special interest because even if research indicates that the overall group of students who score 18 or below on the ACT mathematics portion perform better under the co-requisite model than the pre-requisite model, does that mean that this lower performing group also performs better under the co-requisite model than the pre-requisite model? Specifically, does one model work better for all remedial mathematic students? This is the gap this research addresses regarding the time of delivery for learning support mathematics courses.

At this time, all community colleges in Tennessee have been mandated to use the co-requisite model for teaching remedial mathematics per TBR's co-requisite remediation policy (TBR, 2018a). The co-requisite model is delivered in a modular format. It is taught in a computer lab using the Pearson educational product MyLabsPlus. Video lectures, homework problems, quizzes, as well as exams can be found in MyLabsPlus. There are three different methods of delivery for the co-requisite course. These are fully module, module with a traditional lecture component, and fully on-line (module-based). The purpose of the module-based delivery format is that it allows students to be self-directed learners as it is self-paced and allows students the capacity to work from anywhere at any time. Are remedial mathematics students ready for fully module-based, or do they work better when an instructor guides at least part of the class, as is the case in the module-based with a traditional lecture component? It is

important to note that adding the traditional lecture component to the module-based format is new at SSCC. The Fall 2016 semester was the first semester where adding a traditional lecture component to the module-based course was allowed. Therefore, this is a gap this research will address. Overall, this study will address which of these delivery methods works best for remedial mathematics students.

Summary of Literature Review

Literature claims that the co-requisite model of mathematics increases success rates for remedial mathematics students in both their remedial as well as their corresponding introductory college-level mathematics course. Benefits of the co-requisite model include the self-paced nature, the ability of the student to enroll simultaneously in an introductory college-level mathematics course, as well as the self-directed learning nature of the course that allows students to focus on what they need the most. The methodology for this study is explained in chapter three followed by data analysis. The data in this study was analyzed to determine if the results match what the literature claims. Data was also analyzed to determine which delivery method works better for remedial mathematics students at SSCC.

<u>Chapter Three</u>

Methodology

The purpose of this study is to determine the optimal timing and delivery method for teaching remedial mathematics. Students who score 18 or lower on the mathematics portion of the ACT or equivalent test are required to take remedial mathematics courses. Remedial mathematics courses are now often referred to as learning support courses. This study compared success rates of students in the pre-requisite learning support mathematics courses to the co-requisite learning support mathematics courses as well as compared the success rates of students taking the various delivery methods for teaching the remedial mathematics classes.

Under the pre-requisite model, students were required to take learning support mathematics courses prior to taking college-level mathematics courses. Under the co-requisite model, students take learning support mathematics courses at the same time as college-level mathematics courses. The learning support mathematics course is paired with the corresponding college-level mathematics course with the goal of providing just in time remediation for the college-level topics.

First, this study compared the success rates of students who score 18 or below on the mathematics portion of the ACT who took the previous pre-requisite learning support model for teaching remedial mathematics to the new co-requisite learning support model at Sunrise Southern Community College (SSCC). In addition, this study examined success rates of students who scored less than 14 on the mathematics portion of the ACT who took a pre-requisite learning support mathematics course and those who took the co-requisite learning support mathematics course. The pre-requisite learning support model was fully launched at SSCC during the 2013-2014 academic year. Specifically, Math 0810 was fully launched during the Fall

2013 semester and Math 0820 was fully launched during the Spring 2014 semester. The co-requisite learning support model was initiated and fully launched during the Fall 2015 semester. Last, this study compared the success rates of students in the three main delivery methods for teaching learning support mathematics. The three main delivery methods are: fully module, module-based with traditional lecture included, fully on-line module-based. Module-based courses are taught in a computer lab with everything the student needs for learning (video lectures, homework assignments, quizzes, review problems, and exams) predesigned using Pearson's learning product, mylabsplus. Existing data for this research was provided by the institutional research department at SSCC. The following research questions guide this study:

1. What is the difference in the mean pass rates of students who took a co-requisite learning support mathematics course compared to those who took a pre-requisite learning support mathematics course at SSCC?

2. What is the difference in the mean pass rates of students who scored less than 14 on the mathematics portion of the ACT who took a co-requisite learning support mathematics course compared to those who took a pre-requisite learning support mathematics course at SSCC?

3. What is the difference in the mean pass rates of students in fully module, module that includes a traditional lecture, and fully on-line learning support mathematics courses that are module-based at SSCC?

This chapter begins by describing the details of the research design. The research context as well as the population and sample for this study are introduced next. The independent and dependent variables as well as the hypothesis are defined for each research question. The database as well as data collection methods are described. This chapter concludes with details of

how the data was analyzed, a discussion of reliability and validity, ethical considerations, and research assumptions and bias.

Research Design

This was a quantitative study. This study used descriptive statistics and proportion comparison. In descriptive statistics, statistics such as means and proportions are used to describe a group of items (Newcomer & Conger, 2010). This research used a comparative study design. Specifically, this research compared the mean pass rates of students taking remedial mathematics under the different models. It is important to note that the content and assessment are similar in the pre-requisite learning support courses (Math 0810/Math 0820) and the co-requisite learning support course (Math 0530); however, there are differences. Both pre-requisite and co-requisite learning support courses contain state mandated competency content that includes the following algebra based topics: real number sense and operations, algebraic expressions, solving equations, analyzing graphs, and critical thinking. The difference between the content in the two models is that the co-requisite learning support course (Math 0530) contains material that supports the corresponding college level course (Math 1530) in addition to the state mandated competencies. Both pre-requisite learning support and co-requisite learning support courses require that all state mandated competencies are assessed and passed at 70% or higher in order to pass the course exams (Southwest Tennessee Community College, 2018b, p. 3).

The method of assessment for both is a closed-book, closed-notes, proctored exam taken at the completion of each module. It is also noteworthy that the content and assessment is the same for students who took 0530 under the various delivery methods. The content and assessment is also the same for the students who took Math 1530 during the Fall 2015 semester, which will be used as the control group.

First this study compared the mean pass rates of students taking Math 0810 and Math 0820, the pre-requisite learning support courses, and the mean pass rates of students taking the Math 0530 co-requisite learning support course. Next, this study compared the mean pass rates of students taking the pre-requisite learning support courses to those taking the co-requisite learning support courses specifically for those students who score below 14 on the mathematics portion of the ACT. Last, this study compared the mean pass rates of students in the three different delivery formats for remedial mathematics: fully module, module that includes a traditional lecture, and fully on-line. The comparative design study is the best design for this research since the purpose of the study is to compare success rates of students in the different models and delivery methods for teaching remedial mathematics. Archival data for this study was provided by the institutional research department at SSCC.

Research Context

All three research questions of the study were conducted using data from students attending SSCC. SSCC, located in the Mid-South region of the United States, is a community college that is governed by the Tennessee Board of Regents (TBR). Students from SSCC are relevant for this study as there are a large number of SSCC students who require remediation in mathematics. In fact, the average score for the math portion of the ACT for a student at SSCC is 16 (Southwest Tennessee Community College, 2018a). There are more students in need of remediation at SSCC than other community colleges in Tennessee. In addition, SSCC's graduation rate is only 9% (Southwest Tennessee Community College, 2017, p. 1). The national community college graduation rate is 39% (Fain, 2015). Both SSCC and the national community college graduation rates are based on 6-year averages.

Population

For research question one, the population was comprised of all remedial mathematics students from SSCC who took the pre-requisite learning support mathematics courses or the co-requisite learning support mathematics courses. For research question two, the population was comprised of all remedial mathematics students at SSCC who scored less than 14 on the ACT (or equivalent test) and took the pre-requisite learning support mathematics courses or the co-requisite learning support mathematics courses. For research question three, the population was comprised of all remedial mathematics students at SSCC who took MATH 0530, the support course for MATH 1530, Elementary Statistics. In other words, MATH 0530 is the co-requisite learning support course for remedial students who are taking MATH 1530.

Sample

The sample included SSCC students who took remedial mathematics classes. A specific description of the sample for each research question is discussed in detail and organized by research question. It is important to identify the sampling procedure and the criteria used to select the sample for a study. The sampling procedure that was used in this study is a cluster sample. A cluster sample is used when the subjects can be organized by logically formed groups (Brase & Brase, 2016). In this study, the cluster was academic years or semesters. A cluster sample makes sense for this study as the models and methods for teaching remedial mathematics vary by academic years, or sometimes, semesters. The specific academic year or semester used for the cluster as well as the criteria varies based on the individual research question. These are organized by research question below.

Research question 1. In research question one, the mean pass rates of students who took a co-requisite learning support mathematics course are compared to those who took the pre-

requisite learning support mathematics course to determine if there is a significant difference. The sample includes remedial mathematics students from SSCC who took the pre-requisite learning support mathematics courses during the 2014-2015 academic year. Specifically, it consists of students who took 0810 during the Fall 2014 semester and 0820 during the Spring 2015 semester. This sample also includes students from SSCC who took the co-requisite learning support mathematics course during the 2015-2016 academic year (specifically 0530 during the Fall 2015 semester and Spring 2016 semester). The 2014-2015 academic year was chosen for the pre-requisite learning support students as that was the last academic year where the pre-requisite learning support model was used exclusively at SSCC. The 2015-2016 academic year was chosen for the co-requisite learning support model as that was the first academic year where the co-requisite model was fully implemented and therefore used exclusively at SSCC for teaching remedial mathematics.

Research question 2. In research question two, the mean pass rates of students who scored less than 14 on the mathematics portion of the ACT (or equivalent test) and took a co-requisite learning support mathematics course are compared to those who took the pre-requisite learning support mathematics course to determine if there is a significant difference. The sample includes remedial mathematics students from SSCC who scored less than 14 on the ACT (or equivalent test) and who took the pre-requisite learning support mathematics courses during the 2014-2015 academic year (specifically 0810 during the Fall 2014 semester and 0820 during the Spring 2015 semester) and students from SSCC who took the co-requisite learning support mathematics course during the 2015-2016 academic year (specifically 0530 during the Fall 2015 and Spring 2016 semesters).

Research question 3. In research question three, the mean pass rates of students taking the three main delivery methods for remedial mathematics are compared to determine if there is a significant difference. The sample for the fully module course includes remedial mathematics students from SSCC who took MATH 0530 during the Spring 2016 semester. This semester was selected as it was the last semester where traditional lectures were not included in the module courses thus making it a fully module course. The sample for the module course that includes a traditional lecture element includes remedial mathematics students from SSCC who took MATH 0530 during the Spring 2017 semester. This semester was selected as it was the first semester where including a traditional lecture as part of the module course was required. The sample for the fully on-line course that is module-based includes remedial mathematics students from SSCC who took MATH 0530 during the Spring 2017 semester.

The data analyzed in this study was provided by the institutional research department at SSCC. This data was pulled from the Banner system. This study used overall pass rates for specified courses. Individual grades were not used in this study. It is important to note that only pass rates for subjects taking the courses for the first time were used. No identifiable human subjects were used in the study. Therefore, there are no IRB issues to address.

Variables

This section is organized by research question. In other words, the variables are defined and discussed for each research question.

Research question 1.   In reference to research question one, the mean pass rates of students who took a co-requisite learning support mathematics course were compared to those who took the pre-requisite learning support mathematics course to determine if there is a significant difference. There are two variables: the mean pass rate and the model used to teach

the remedial mathematics course. In other words, the variables for this research question include the mean pass rate and model used to teach the remedial mathematics class where model refers to either pre-requisite or co-requisite. The model used to teach the remedial mathematics course is the independent variable. The mean pass rate is the dependent variable. First, this study examined the mean pass rate of students in the pre-requisite learning support mathematics courses during the 2014-2015 academic year and the mean pass rate of students in the co-requisite learning support mathematics course during the 2015-2016 academic year. These pass rates were compared to determine if there is a statistically significant difference between them, and if so, to determine which model leads to the better pass rate.

  Research question 2. In reference to research question two, the mean pass rates of students who scored less than 14 on the mathematics portion of the ACT (or equivalent test) and took a co-requisite learning support mathematics course were compared to those who took the pre-requisite learning support mathematics course to determine if there is a significant difference. There are two variables: The mean pass rate and the model used to teach the remedial mathematics course to those students who scored less than 14 on the mathematics portion of the ACT. The model (pre-requisite learning support or co-requisite learning support) is the independent variable. The mean pass rate is the dependent variable. First, this study examined the mean pass rate of students who scored less than 14 on the mathematics portion of the ACT in the pre-requisite learning support mathematics courses during the 2014-2015 academic year and the mean pass rate of the students in the co-requisite learning support mathematics course during the 2015-2016 academic year. These pass rates were compared to determine if there is a statistically significant difference between them, and if so, to determine which model leads to the better pass rate.

Research question 3. In reference to research question three, the mean pass rates of students taking the three main delivery methods for remedial mathematics were compared to determine if there is a significant difference. The delivery method used to teach the remedial mathematics course is the independent variable. The mean pass rate is the dependent variable. These pass rates were compared to determine if there is a statistically significant difference between them, and if so, to determine which delivery method leads to the better pass rate.

Hypotheses

This section is organized by research question. In other words, the hypotheses are stated and discussed for each of the three research questions.

Research question 1. The goal of research question one is to compare the mean pass rates of remedial mathematics students taking pre-requisite learning support and co-requisite learning support courses. The pass rate for each is expressed as a proportion. The null hypothesis is that there is no difference between the two proportions. The alternative hypothesis is that there is a difference between the two proportions.

Research question 2. The goal of research question two is to compare the mean pass rates of remedial mathematics students taking pre-requisite learning support and co-requisite learning support courses who scored less than 14 on the mathematics portion of the ACT. The pass rate for each is expressed as a proportion. The null hypothesis is that there is no difference between the two proportions. The alternative hypothesis is that there is a difference between the two proportions.

Research question 3. The goal of research question three is to compare the mean pass rates of students taking the three main delivery methods for remedial mathematics to determine if there is a significant difference. The pass rate for each is expressed as a proportion. The null

42

hypothesis is that there is no difference between the proportions. The alternative hypothesis is that there is a difference between the proportions.

Database Description and Data Collection

The archival data that was analyzed in this study was provided by the institutional research department at SSCC. This data was pulled from the Banner system. Banner is the system used by faculty to enter final grades for students. Banner stores and displays this data. Banner is a world leading higher education solution of choice. Banner has been in development for over 30 years and is used by almost 1,400 institutions worldwide (Ellucian, 2018). For remedial mathematics classes, only grades of pass or fail are entered by faculty. Specifically, faculty enters a grade of pass or fail in Banner for each student. This study used the archival data that shows pass rates for the students in the previously defined samples for each research question. I initiated a request for this data. Specifically, I sent an email request to the SSCC institutional research department requesting the specific data needed for this study. This email request was sent in January 2018.

Method of Data Analysis

This study focused on the pass rates of students in the two different remedial mathematics models as well as the three different delivery methods. The pass rates of each were expressed as proportions. A test of proportions was used to analyze the data for the first two research questions. This method was chosen for the data analysis because the research questions required a hypothesis test that involves comparing proportions. A z-test statistic was calculated. The z-test statistic is the appropriate test statistic to use when comparing proportions (Hinkle, Wiersma, & Jurs, 2003). This data was analyzed using an online TI-83 calculator. A chi-square test was used to analyze the data for the third research question. A chi-square test statistic was calculated.

The chi-square test statistic is the appropriate test statistic to use since there are three delivery methods being compared (Ibid.). This data was also analyzed using an online TI-83 calculator. This section is organized by the three research questions that are guiding the study.

Research question 1. Is there a significant difference in the mean pass rates of students who took the co-requisite courses learning support mathematics courses than the previous pre-requisite learning support mathematics courses? The pass rates of each were expressed as proportions and then a z-test statistic was calculated using an online TI-83 calculator as the tool for the analysis. The purpose of the test of proportions is to determine if there was a statistically significant difference between the proportions that represented the mean pass rates of the two groups of students. Data is organized as shown in Table 1 below.

Table 1

Proportions and Mean Pass Rates for Pre-requisite Students and Co-requisite Students

	Number of Students Who Passed	Total Number of Students	Proportion	Mean Pass Rate Expressed as a Percentage
Pre-requisite 2014-2015				
Co-requisite 2015-2016				

Hypothesis testing was conducted to compare the two proportions. The mean success rate of the students who took remedial mathematics under the pre-requisite learning support model was used to calculate the first proportion in the table, and the mean success rate of the

students who took remedial mathematics under the co-requisite learning support model was used to calculate the second proportion in the table. The null hypothesis states that there is no difference between the two proportions. The alternative hypothesis states that there is a difference between the two proportions. A z-test statistic was calculated along with a *p*-value.

A 5% level of significance, $\alpha = .05$, was used for this test. A 5% level of significance is typically used for testing statistical hypothesis in social sciences and public affairs (Brase & Brase, 2016, p. 430). This is especially true for larger samples sizes. The level of significance is the probability of rejecting the original claim, that the mean pass rates are equal, when it is true (Brase & Brase, 2016).

Research question 2. Is there a significant difference in the mean pass rates of students who scored less than 14 on the mathematics portion of the ACT and took the co-requisite courses learning support mathematics courses than the previous pre-requisite learning support mathematics courses? The pass rates of each were expressed as proportions and then a z-test statistic was calculated using an online TI-83 calculator. The purpose of the test of proportions was to determine if there was a statistically significant difference between the proportions that represented the mean pass rates of the two groups of students. Data is organized as shown in Table 2 below.

Table 2

Proportions and Mean Pass Rates for Pre-requisite and Co-requisite Students who Scored Less Than 14 on the Mathematics Portion of the ACT

	Number of Students Who Passed	Total Number of Students	Proportion	Mean Pass Rate Expressed as a Percentage
Pre-requisite 2014-2015 less than 14 ACT				
Co-requisite 2015- 2016 less than 14 ACT				

A 5% level of significance, $\alpha = .05$, was used for this test. Hypothesis testing was conducted to compare the two proportions. The mean success rate of students who scored less than 14 on the mathematics portion of the ACT who took remedial mathematics under the pre-requisite learning support model was used for the first proportion in the table. The mean success rate of the students who scored less than 14 on the mathematics portion of the ACT who took remedial mathematics under the co-requisite model was used for the next proportion in the table. The null hypothesis states that there is no difference between the two proportions. The alternative hypothesis states that there is a difference between the two proportions. A z-test statistic was calculated along with a *p*-value.

Research question 3. Is there a significant difference in the mean pass rates of students who took remedial mathematics in a fully module course, a module course that includes

traditional lecture, and a fully on-line course that is module-based? A chi-square test of

independence was done and a chi-square test statistic was calculated using an online TI-83

calculator. The purpose of the chi-square test was to determine if the delivery method and the

pass rates of students in the delivery methods are independent. Data is organized as shown in

Table 3 below.

Table 3

Proportions and Mean Pass Rates for Remedial Mathematics Students in Three Different Delivery Methods

	Number of Students Who Passed	Total Number of Students	Proportion	Mean Pass Rate Expressed as a Percentage
Fully module				
Module with lecture				
Fully on-line				

A 5% level of significance, $\alpha = .05$, was used for this test. Hypothesis testing was

conducted. The mean success rate of students in the fully module remedial mathematics course

was used for the first proportion in the table. The mean success rate of the students in the

module course that includes some traditional lecture was used for the next proportion in the

table. The mean success rate of students in the on-line (module-based) course was used for the

third proportion in the table. The null hypothesis states that delivery method and pass rates are

independent, or there is no difference between the three proportions. The alternative hypothesis

states that delivery method and pass rate are not independent, or there is a difference between at

least one set of the three proportions. A chi-square test statistic was calculated along with a *p*-value.

Validity and Reliability

Regarding the validity and reliability of the data, the exact data, (proportions that represent pass rates) that was provided by the SSCC institutional research department was used in the data analysis for this study. Final grades (from Banner) were used to determine pass rates. Pass rates are the measurement used to make comparisons in this study. Passing a remedial mathematics course is defined by the student scoring 70% or higher on all module exams (Southwest Tennessee Community College, 2018b, p. 3).

Pass rates provided by the SSCC institutional research department are accurate due to the fact that final grades as entered by faculty were used. Therefore, this data should not have issues of validity. Since the data that was used in this study originated from Banner, it is also reliable.

This data in this study was analyzed using a test of proportions that represents mean pass rates. Therefore, tests for collinearity, homogeneity, and normal distributions were not necessary. In other words, proportions instead of individual data were used in the proportion testing.

Ethical Considerations

Ethical considerations are always an important part of research. It should be the goal of the researcher to ensure all participants are protected. Specifically participants' identity should be protected. In this study, there is no link between grades and individuals. Overall mean pass rates of courses were used for the statistic in the analysis.

Research Assumptions

For the purposes of this research, several assumptions were made. First, it was assumed that all instructors and professors grade fairly and honestly. Second, it was assumed that all instructors and professors enter grades without error. These are reasonable assumptions as both are required of faculty at SSCC.

Research Bias

I am currently an Associate Professor of Mathematics at SSCC. I also have experience teaching the courses included in this research. However, since overall pass rates of students under the various models of teaching remedial mathematics were used in this study, my personal bias should not influence the results of the study.

Conclusion

This study used a comparative research design for a quantitative study. Descriptive statistics and proportion comparison were used to compare mean pass rates of students taking remedial mathematics under the various models and methods for teaching remedial mathematics at SSCC. A cluster sampling procedure was used and mean pass rates from specific years and semesters was included in the study. Data was provided by the institutional research department at SSCC. The data was analyzed using an online TI-83 calculator. The results of the three tests are provided in detail in chapter four. A discussion of the results follow in chapter five.

Chapter Four

Results

The purpose of this study was to compare the competing models (pre-requisite learning support and co-requisite learning support) and delivery methods (fully module, module with a traditional lecture component, and fully on-line) presented to determine the better overall approach to teaching remedial mathematics. This study used a comparative study design to compare the mean pass rates of students who took remedial mathematics under the different models and delivery methods presented. Data for all three research questions was provided by the institutional research department at SSCC. Secondary analysis of this existing data was conducted. A test of proportions was used to analyze the data for the first two research questions. The data was analyzed using a TI-83 calculator. A chi-square test was used to analyze the data for the third research question. This chapter will provide the results of this data analysis that was performed to address the guiding research questions for this study:

RQ1. What is the difference in the mean pass rates of students who took a co-requisite learning support mathematics course compared to those who took a pre-requisite learning support mathematics course at SSCC?

RS2. What is the difference in the mean pass rates of students who scored less than 14 on the mathematics portion of the ACT who took a co-requisite learning support mathematics course compared to those who took a pre-requisite learning support mathematics course at SSCC?

RS3. What is the difference in the mean pass rates of students in fully module, module that includes a traditional lecture, and fully on-line learning support mathematics courses that are module-based at SSCC?

Results for Research Question One

The first research question is: Is there a significant difference in the mean pass rates of students who took a co-requisite learning support mathematics course compared to those who took a pre-requisite learning support mathematics course at SSCC? A sample of 1602 students, $n = 1602$, was used for pre-requisite learning support mathematics courses. A sample of 1269 students, $n = 1269$, was used for the co-requisite learning support mathematics course. This data is organized as displayed in Table 4.

Table 4

Proportions and Mean Pass Rates for Pre-requisite Students and Co-requisite Students

	Number of Students Who Passed	Total Number of Students	Proportion	Mean Pass Rate Expressed as a Percentage
Pre-requisite 2014-2015	127	1602	127/1602	7.93 percent
Co-requisite 2015-2016	816	1269	816/1269	64.3 percent

A test of proportions was used to compare the pass rates of the competing models. A hypothesis test was conducted to compare the two proportions. The null hypothesis states that there is no difference between the two proportions. The alternative hypothesis states that there is a difference between the two proportions. A 5% level of significance, $\alpha = 0.05$, was used for this test.

Proportions that represent the mean pass rates of students are displayed in the table. The mean pass rate of the students who took remedial mathematics under the pre-requisite learning support model was used to calculate the first proportion in the table. The mean pass rate of the students who took remedial mathematics under the co-requisite learning support model was used to calculate the second proportion in the table.

This data was analyzed using a TI-83 calculator. A z-test statistic and a p-value were calculated to determine if there is a statistically significant difference between the proportions that represented the mean pass rates of the two groups of students. The following formula was used to calculate the z-test statistic in this study:

$$z = (\hat{p}_1 - \hat{p}_2)/[(\overline{pq}/n_1) + (\overline{pq}/n_2)]^{1/2} \tag{1}$$

In the z-test statistic formula, $\hat{p}_1$ is the proportion that correlates to the mean pass rate of students in pre-requisite learning support remedial mathematics courses, $\hat{p}_2$ is the proportion that correlates to the mean pass rate of students in co-requisite remedial mathematics courses, $\overline{p}$ represents the pooled estimate proportion, $\overline{q}$ is $1 - \overline{p}$, n_1 is the number of students in the pre-requisite learning support sample, and n_2 is the number of students in the co-requisite learning support sample. The test statistic, $z = -31.94$, $p < 0.01$ indicates that at the 5% level of significance, the mean pass rates of students from the pre-requisite and the co-requisite models for teaching remedial mathematics were significantly different. These results are displayed in Table 5.

Table 5

Sample Sizes, Proportions, Test Statistic, and P-value for Pre-requisite Learning Support Students and Co-requisite Students

	N	$\hat{p}$	Z	P-value
Learning support 2014-2015	1602	.079	-31.94	< 0.01
Co-requisite Fall 2015	1269	.643		

Results for Research Question Two

The second research question is: Is there a significant difference in the mean pass rates of students who scored less than 14 on the mathematics portion of the ACT and took the co-requisite learning support mathematics course compared to those who took a pre-requisite learning support mathematics course at SSCC? A sample of 333 students, $n = 333$, was used for pre-requisite learning support mathematics courses. A sample of 277 students, $n = 277$, was used for the co-requisite learning support mathematics course. This data is organized as displayed in Table 6.

Table 6

Proportions and Mean Pass Rates for Pre-requisite Students and Co-requisite Students (ACT < 14)

	Number of Students Who Passed	Total Number of Students	Proportion	Mean Pass Rate Expressed as a Percentage
Pre-requisite 2014-2015	24	333	24/333	7.21 percent
Co-requisite 2015-2016	165	277	165/277	59.6 percent

A test of proportions was used to compare the pass rates of the competing models. A hypothesis test was conducted to compare the two proportions. The null hypothesis states that there is no difference between the two proportions. The alternative hypothesis states that there is a difference between the two proportions. A 5% level of significance, $\alpha = 0.05$, was used for this test.

Proportions that represent the mean pass rates of students are displayed in the table. The mean pass rate of the students who took remedial mathematics under the pre-requisite learning support model was used to calculate the first proportion in the table. The mean pass rate of the students who took remedial mathematics under the co-requisite learning support model was used to calculate the second proportion in the table.

This data was analyzed using a TI-83 calculator. A z-test statistic and a *p*-value were calculated to determine if there is a statistically significant difference between the proportions

that represented the mean pass rates of the two groups of students. The following formula was

used to calculate the z-test statistic in this study:

$$z = (\hat{p}_1 - \hat{p}_2)/[(\overline{pq}/n_1) + (\overline{pq}/n_2)]^{1/2} \qquad (2)$$

In the z-test statistic formula, $\hat{p}_1$ is the proportion that correlates to the mean pass rate of students

in pre-requisite learning support remedial mathematics courses, $\hat{p}_2$ is the proportion that

correlates to the mean pass rate of students in co-requisite remedial mathematics courses, $\overline{p}$

represents the pooled estimate proportion, $\overline{q}$ is $1 - \overline{p}$, n_1 is the number of students in the pre-

requisite learning support sample, and n_2 is the number of students in the co-requisite learning

support sample. The test statistic, $z = -13.92$, $p < 0.01$ indicates that at the 5% level of

significance, the mean pass rates of students who scored below 14 on the mathematics portion of

the ACT from the learning support and the co-requisite models for teaching remedial

mathematics were significantly different. These results are displayed in Table 7.

Table 7

Sample Sizes, Proportions, Test Statistic, and P-value for Pre-requisite Learning Support
Students and Co-requisite Students (ACT < 14)

	N	$\hat{p}$	Z	P-value
Learning support 2014-2015	333	.072	-13.92	< 0.01
Co-requisite Fall 2015	277	.596		

Results for Research Question Three

The third research question is: Is there a significant difference in the mean pass rates of students who took remedial mathematics in a fully module course, a module course that includes traditional lecture, and a fully on-line course that is module-based at SSCC? A sample of 480 students, $n = 480$, was used for the fully module course. A sample of 331 students, $n = 331$, was used for module course with a lecture component. A sample of 27 students, $n = 27$, was used for the fully on-line courses. This data is organized as displayed in Table 8.

Table 8

Proportions and Mean Pass Rates for Remedial Mathematics Students in Three Different Delivery Methods

	Number of Students Who Passed	Total Number of Students	Proportion	Mean Pass Rate Expressed as a Percentage
Fully module	306	480	306/480	63.75 percent
Module with lecture	237	331	237/331	71.60 percent
Fully on-line	18	27	18/27	66.67 percent

The mean success rate of students in the fully module remedial mathematics course was used for the first proportion in the table. The mean success rate of the students in the module course that includes some traditional lecture was used for the next proportion in the table. The mean success rate of students in the on-line (module-based) course was used for the third proportion in the table.

Hypothesis testing was conducted. The null hypothesis states that there is no difference between the proportions, or delivery method and pass rate are independent. The alternative hypothesis states that there is a difference between at least one set of the proportions, or delivery method and pass rate are not independent. A chi-square test of independence was used to test the hypothesis. A 5% level of significance, $\alpha = 0.05$, was used for this test.

This data was analyzed using a TI-83 calculator. A chi-square test statistic and a *p*-value were calculated to determine if delivery method and pass rate are independent. The following formula was used to calculate the chi-square test statistic in this study:

$$X^2 = \ \Sigma\,[(O - E)^2/\,E] \tag{3}$$

In the chi-square test statistic formula, *O* is the observed frequency and *E* is the expected frequency for each cell. This data is displayed in Tables 9 and 10.

Table 9

Observed Frequencies of Pass and Not Pass for Remedial Mathematics Students in Three Different Delivery Methods

	Pass	*Not Pass*
Fully module	306	174
Module with lecture	237	94
Fully on-line	18	9

Table 10

Expected Frequencies of Pass and Not Pass for Remedial Mathematics Students in Three Different Delivery Methods

	Pass	*Not Pass*
Fully module	321.34	158.66
Module with lecture	221.59	109.41
Fully on-line	18.08	8.92

The test statistic, $X^2 = 5.46$, $p = 0.07$ indicates that at the 5% level of significance, the mean pass rates of students in the three delivery methods presented were not significantly different. These results are displayed in Table 11.

Table 11

Sample Sizes, Proportions, Test Statistic, Degrees of Freedom, and P-value for Remedial Mathematics Students in Three Different Delivery Methods

	N	$\hat{p}$	X^2	*df*	*P*-value
Fully module	480	.638	5.46	2	0.07
Module with lecture	331	.716			
Fully on-line	27	.667			

Control Group

A control group was used in this study to account for potential variability between cohorts. The control group consists of students in Math 1530 during the Fall 2015 semester who

passed 0820 during the Spring 2015 semester. This is the pre-requisite learning support

group. The control group also consists of students in Math 1530 during the Fall 2015 semester

who passed 0530 during the Fall 2015 semester. This is the co-requisite learning support

group. The goal is to determine if there is a significant difference between the pass rate of the

pre-requisite learning support group and the co-requisite learning support group in Math 1530

during the Fall 2015 semester. The pass rate of both the pre-requisite learning support group and

the co-requisite learning support group was calculated in the same course, Math 1530, and during

the same semester, Fall 2015, thus minimizing potential outside variability between the two

cohorts.

The question of interest is: Is there a significant difference in the mean pass rates of

students in Math 1530 who took a co-requisite learning support mathematics course compared to

those who took a pre-requisite learning support mathematics course at SSCC?   A sample of 48

students, $n = 48$, was used for pre-requisite learning support mathematics courses. A sample of

681 students, $n = 681$, was used for the co-requisite learning support mathematics course. This

data is organized as displayed in Table 12.

Table 12

*Proportions and Mean Pass Rates in Math 1530 for Pre-requisite Students and Co-requisite
Students*

	Number of Students Who Passed	Total Number of Students	Proportion	Mean Pass Rate Expressed as a Percentage
Math 1530 (Pre-requisite)	28	48	28/48	58.3 percent
Math 1530 (Co-requisite)	353	681	353/681	51.8 percent

A test of proportions was used to compare the pass rates of the competing models. A hypothesis test was conducted to compare the two proportions. The null hypothesis states that there is no difference between the two proportions. The alternative hypothesis states that there is a difference between the two proportions. A 5% level of significance, $\alpha = 0.05$, was used for this test.

Proportions that represent the mean pass rates of students are displayed in the table. The mean pass rate of the students who took remedial mathematics under the pre-requisite learning support model was used to calculate the first proportion in the table. The mean pass rate of the students who took remedial mathematics under the co-requisite learning support model was used to calculate the second proportion in the table.

This data was analyzed using a TI-83 calculator. A z-test statistic and a *p*-value were calculated to determine if there is a statistically significant difference between the proportions

that represented the mean pass rates of the two groups of students. The following formula was used to calculate the z-test statistic in this study:

$$z = (\hat{p}_1 - \hat{p}_2)/[(\overline{pq}/n_1) + (\overline{pq}/n_2)]^{1/2}$$

In the *z*-test statistic formula, $\hat{p}_1$ is the proportion that correlates to the mean pass rate of students in Math 1530 who took the pre-requisite learning support remedial mathematics courses, $\hat{p}_2$ is the proportion that correlates to the mean pass rate of students in Math 1530 who took the co-requisite remedial mathematics course, $\overline{p}$ represents the pooled estimate proportion, $\overline{q}$ is $1 - \overline{p}$, n_1 is the number of students in the pre-requisite learning support sample, and n_2 is the number of students in the co-requisite learning support sample. The test statistic, $z = 0.87$, $p = .38$ indicates that at the 5% level of significance, the mean pass rates of students who took Math 1530 and the pre-requisite learning support course and those who took Math 1530 and the co-requisite learning support course were not significantly different. These results are displayed in Table 13.

Table 13

Sample Sizes, Proportions, Test Statistic, and P-value for Math 1530 Students in Pre-requisite Learning Support and Co-requisite Learning Support

	N	$\hat{p}$	Z	P-value
Math 1530 (pre-requisite students)	48	.583	0.87	.38
Math 1530 (co-requisite students)	681	.518		

ACT for Cohorts

When comparing pass rates of groups of students from different academic years or semesters, it is helpful to have additional information about the cohorts. Of special interest in this research is the average ACT score (on the mathematics portion). The pre-requisite learning support cohort (2014-2015 academic year) had an average ACT of 15.51; whereas, the co-requisite learning support cohort (2015-2016 academic year) had an average ACT of 15.52. The delivery methods presented utilized cohorts from different semesters. The fully module cohort (Spring 2016) had an average ACT of 15.19. The module with a traditional lecture component cohort (Spring 2017) had an average ACT of 15.38. The fully on-line (module-based) cohort (Spring 2017) had an average ACT of 15.60.

Demographic Information for Cohorts

Another area of interest is the demographic breakdown of the cohorts. Of special interest is race and gender. The pre-requisite learning support cohort (2014-2015 academic year) was

37.01% male and 62.99% female. In regards to race this cohort was 22.26% white, 74.93% black, 0.77% American Indian, and 2.03% Asian. The co-requisite learning support cohort (2015-2016 academic year) was 31.97% male and 68.03% female. In regards to race this cohort was 22.16% white, 75.31% black, 0.57% American Indian, and 1.96% Asian.

The delivery methods presented utilized cohorts from different semesters. The fully module cohort (Spring 2016) was comprised of 32.92% males, 67.08% females, 16.63% white, 80.99% black, 0.65% American Indian, and 1.73% Asian students. For the fully module (with a lecture component) cohort (Spring 2017), 34.44% of the students were males, 65.56% were females, 20.31% was white, 76.88% black, 0.63% was American Indian, and 2.19% was Asian. For the fully on-line cohort (Spring 2017), 22.22% of the students were males, 77.78% were females, 42.31% was white and 57.69% was black (all other races were less than 0.00%).

Summary

The results of the research regarding the better overall model (timing) and method (delivery method) for teaching remedial mathematics were presented in this chapter. The findings indicate that the co-requisite model for teaching remedial mathematics leads to higher pass rates for students in general in their remedial mathematics course. The second research question focused on a special group of students: those who scored below 14 on the mathematics portion of the ACT. The results of this research also indicate that the co-requisite model leads to higher pass rates for this group of students in their remedial mathematics course. Three delivery methods (fully module, fully module with a traditional lecture component, and fully on-line) were also compared to determine the better method of the three for teaching remedial mathematics. The results of this research indicate that there is no significant difference in pass rates of students in the delivery methods presented. Last, research was conducted on a control

group. Findings from the control group research indicate that there is no significant difference in the pass rates of students in their introductory college level mathematics course between those who took remedial mathematics under the pre-requisite model and those who took remedial mathematics under the co-requisite model.   Recommendations and implications of this research will be discussed in chapter five.

Chapter Five

Discussion and Recommendations

This chapter provides a discussion of implications and recommendations of the results of the findings from chapter four. Recommendations will be provided for higher education policy-makers and educators so they can apply what was learned from this research. The purpose of this research was to determine the better model and delivery method of the three presented for teaching remedial mathematics in higher education. A hypothesis test was conducted first to determine the best time to teach remedial mathematics (pre-requisite or co-requisite). Next, the research focused on a sub-group of remedial mathematics students, those who scored less than 14 on the mathematics portion of the ACT. Then, hypothesis testing was conducted to determine the better delivery method of the three presented (fully module, module with a traditional lecture component, and fully on-line) for teaching remedial mathematics. Finally, a hypothesis test was conducted using a control group that consisted of students in their introductory college–level mathematics course. There were two sub-groups in the control group. The first was those who took pre-requisite remedial mathematics. The second was those who took co-requisite remedial mathematics. The hypothesis test was conducted to determine which group performed better in their introductory college–level mathematics course. Interpretations of these findings, implications, and recommendations will be presented, and then a summary will conclude this research.

Interpretation of Findings

At the beginning of this study, this researcher reviewed literature related to the topic of this study. A review of studies involving remedial mathematics as well as delivery methods was conducted. Literature revealed that college students, and especially community college students,

take remedial mathematics at a very high rate. Furthermore, the pass rate of these students in their remedial mathematics courses are alarming low, and dropout rates are high. In fact, remedial mathematics has been labeled "the roadblock to graduation" ("Corequisite Remediation: Spanning the Completion Divide," 2016).

What was missing from literature was a comprehensive study involving the best timing and better delivery methods for teaching remedial mathematics. This is the gap in research that this study seeks to fill. Specifically, this research seeks to determine, how the success rate of this group of students can be maximized. The results of this study indicate that the co-requisite model for teaching remedial mathematics leads to significantly higher pass rates of students, including those who scored below 14 on the mathematics portion of the ACT, in their remedial mathematics course. Results of this study also indicate that there is no significant difference in the mean pass rates of students who took remedial mathematics under the delivery methods presented.

A control group, consisting of those who took pre-requisite learning support and those who took co-requisite learning support, was utilized to determine the pass rates of each group in their introductory college-level mathematics course. The result of this study was that there was no significant difference in the pass rates of students in their introductory college level mathematics course between those who took remedial mathematics under the pre-requisite model and those who took remedial mathematics under the co-requisite model. It is interesting that the students who took learning support as a co-requisite course passed at significantly higher rates than those who took learning support as a pre-requisite course, while both groups of students passed 1530 at similar rates. It is this researcher's belief that this supports the assertion that remedial mathematics was the road block to graduation. Once a student passes remedial

mathematics (learning support), whether it was taught as a pre-requisite or co-requisite course, the student is prepared for their introductory college-level mathematics course.

Self-directed learning is the adult learning theory that guided this research. Both the pre-requisite model and co-requisite model for teaching remedial mathematics utilize concepts from self-directed learning. Key elements of self-directed learning include taking the initiative for, control of, and responsibility for one's own learning. According to Boucouvalas and Lawrence (2010), self-directed learning is the growing ability to know how to learn, when there is a need to be taught, and to increasing take responsibility for one's own learning as well as non-learning. Adult learners are those who are capable of directing their own learning and are internally motivated (Hansman & Mott, 2010). According to Hansman (2001), self-directed learning occurs as learners practice doing the task. The pre-requisite as well as co-requisite learning support models and the various delivery methods presented in this research include these key elements of self-directed learning. Specifically, students are in control of their own learning. Both learning support models as well as all three delivery methods were taught in a module format which allows students to work at their own pace, learn on their own, work ahead, and reach out to the instructor for assistance when needed.

It is important for students in these delivery models and methods to be, or increasingly become, self-directed in their learning. It is also important the adult educators understand when to teach and when to give the student room to teach his or herself. Adult educators need to help students become increasingly self-directed in their learning. This is the goal of the Staged Self-Directed Learning (SSDL) model (Grow, 1991). This model consists of four stages: a dependent student and a teacher as a coach, an interested student and a teacher who is a guide, an involved student and a teacher who is a facilitator, and in stage four the learner is self-directed and the

teacher is a consultant. The models and methods presented in this research allow room for

students to move through these stages. According to Grow (1994), every stage requires a

balance between the student's growing self-direction and the teacher's role based on what stage

of self-directed learning the student is in at the time. Grow also asserts that the teacher is the

best judge of the self-directed readiness level of a student. Therefore, it is important for teachers

to meet the student where he or she is and facilitate the growth of self-directed learning.

According to Grow, becoming a self-directed learner is the most important outcome for adult

learners in a formal educational setting. The module-based format of the delivery times and

methods presented in this research allow room for this growth in the area of self-directed

learning.

Implications

There are several implications of this study. First, the time of delivery does matter.

Results of this study imply that teaching remedial mathematics as a co-requite leads to higher

success rates. Of special interest was the sub-group of students who scored below 14 on the

mathematics portion of the ACT. Results of this research indicate that this sub-group had

significantly higher pass rates under the co-requisite model than the pre-requisite model as well.

Second, results did not indicate that the delivery method made a significant difference in

pass rates. The three methods included in this study were fully module, fully module with a

traditional lecture component, and fully on-line.

Last, results of the control group imply that there is no statistically significant difference

in the pass rates of students in their introductory college level course for those who took remedial

mathematics as a pre-requisite versus those who took remedial mathematics as a co-requisite.

This could be due to the sample size of the pre-requisite cohort being too small to rule out the

observed difference was due to chance. The smaller percent of students who passed learning support as a pre-requisite could also indicate that the stronger students of this group moved forward and took Math 1530.

In summary, the co-requisite model for teaching remedial mathematics leads to significantly higher pass rates for students in remedial mathematics courses. Since the co-requisite model leads to higher pass rates, and takes only one semester to complete as opposed to the two semesters required to complete the pre-requisite learning support courses, it seems the co-requisite model is the better option.

Recommendations

The results of this research indicate that it is better to teach remedial mathematics as a one-semester co-requisite course. In other words, students pass remedial mathematics at a significantly higher rate when taking it at the same time as their corresponding college-level course. Therefore, this researcher recommends that remedial mathematics be taught as a co-requisite course that is taken at the same time as the corresponding college-level mathematics course. It is also recommended to continue to offer the co-requisite in a format where it can be completed in one semester. Last, it is important to continue to offer the co-requisite in a format that will continue to allow for students to grow in their self-directed learning ability. The current module-based format offers this flexibility.

The results of this research did not show a statistically significant difference in the pass rate of students in their introductory college-level mathematics course between those who passed learning support (or remedial mathematics) as a pre-requisite versus a co-requisite. This researcher recommends future research to ensure pass rates of co-requisite students in their introductory college-level mathematics course are not significantly lower. The results of this

research also did not show a significant difference in the pass rates of students in their remedial mathematics course taken under the presented delivery methods. It is important to note that students are often not aware of what they are choosing when selecting a course's delivery method. Colleges should ensure that students are aware of the requirements of the various delivery methods.   Future research is needed in the area of which delivery method works better for students with different learning styles. Although there are varying opinions regarding the effectiveness of learning assessments, this researcher recommends that students complete a learning assessment when advised to help identify the best delivery method for each student.

Adult educators and policy makers should continue to search for the best overall to teaching remedial mathematics. Continued research in this area would be beneficial to both educators and students in remedial mathematics in higher education. More research is needed in the area of the best delivery method. Three main delivery methods were presented in this research. Future research should include additional delivery methods such as hybrid courses (half traditional lecture and half on-line). Future research should also include the impact high impact practices such as learning communities, mentors, and supplemental instruction has on the pass rates of students in remedial mathematics courses as well as their corresponding college-level courses. Adult educators should continue strive to help students become more self-directed in their learning. This researcher recommends that higher education institutions offer training for adult educators to help them learn how to help students become more self-directed in their learning.

Summary

This chapter provided an overview of the results of the research that was conducted in chapter four. The results of this research provided insight into the overall best time and better

delivery method for teaching remedial mathematics in higher education. The results of this research indicated that the co-requisite model for teaching remedial mathematics led to significantly higher pass rates; therefore, it is the recommendation of this researcher to continue to offer remedial mathematics as a one-semester course that is taught at the same time as the corresponding introductory college-level mathematics course. This researcher also recommends future research in the area of pass rates in the introductory college-level mathematics courses as well as delivery methods for teaching remedial mathematics in higher education. Finally, facilitating the growth of students in the area of self-directed learning should continue to be a goal of educators in higher education. Educators should continue to offer remedial education in a format that allows for this growth.

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